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HIGH PRODUCTION VOLUME (HPV)

CHALLENGE PROGRAM

FINAL SUBMNISSION

For

SUCCINIMIDE DISPERSANTS

Prepared by
The American Chemistry Council
Petroleum Additives Panel
Health, Environmental and Regulatory Task Group

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LIST OF MEMBER COMPANIES IN THE HEALTH, ENVIRONMENTAL AND REGULATORY TASK GROUP

The Petroleum Additives Panel Health, Environmental and Regulatory Task Group of the American Chemistry Council includes the following member companies:

Afton Chemical Company (formerly Ethyl Corporation)

Chevron Oronite Company, LLC

Infineum

The Lubrizol Corporation

EXECUTIVE SUMMARY

The American Chemistry Council Petroleum Additives Panel Health, Environmental and Regulatory Task Group, and its member companies, hereby make the final submission for the *"Succinimide dispersant"* category of chemicals under the United States Environmental Protection Agency High Production Volume (HPV) Chemical Challenge Program.

Succinimide Dispersant Category. The following two closely related chemicals constitute a chemical category:

- 2,5-Pyrrolidinedione,1-[2-[[2-[[2-[(2-aminoethyl)amino]ethyl]amino]ethyl]amino] ethyl]-, monopolyisobutenyl derivatives – (CAS # 67762-72-5), referred to as "mono alkenyl succinimide derivative".
- Amines, polyethylenepoly-, reaction products with succinic anhydride polyisobutenyl derivatives – (CAS # 84605-20-9), referred to as "bis alkenyl succinimide derivative".

Structural Similarity. A key factor supporting the classification of these chemicals as a category is their structural similarity. All substances in this category consist of a polyisobutylene succinic anhydride structure with polyethylene polyamine substituent groups.

Similarity of Physicochemical Properties. The similarity of the *physicochemical properties* of these substances parallels their structural similarity. All are dark colored viscous liquids intended for use as components in finished lubricating oils. The use of these substances in finished lubricants requires that they be stable under high temperatures (>100^{o}C). Their low volatility is due to their low vapor pressure, high viscosity and relatively high molecular weights. The existing information for these substances indicates that they have low water solubility.

Fate and Transport Characteristics. Members of this category have been shown to be poorly biodegradable. Since the members of this category have low water solubility, hydrolysis testing is technically unfeasible. Furthermore, members of the category are resistant to hydrolysis because they lack hydrolyzable moieties. This makes hydrolysis modeling unnecessary. Photodegradation is not expected to cause significant physical degradation of succinimide dispersants. However, computer-modeled data was developed to adequately characterize the potential atmospheric oxidation potential for members of this category. These substances are not expected to partition into water or into air if released into the environment due to their low water solubility and low vapor pressure and computer-modeled environmental partitioning data indicates that these substances will partition into soil and sediment.

Toxicological Similarity. Review of existing published and unpublished test data for succinimide dispersants shows the aquatic and mammalian toxicity of the two substances within this category are similar and are of a low concern.

> *Aquatic Toxicology.* Data on acute fish toxicity, acute invertebrate toxicity, and alga toxicity were reviewed and the findings indicate little to no toxicity.

Mammalian Toxicology - Acute. Data on acute mammalian toxicity were reviewed, and the findings indicate a low concern for acute toxicity.

Mammalian Toxicology - Mutagenicity. Data from bacterial reverse mutation assays and *in vitro* and *in vivo* chromosome aberration studies were reviewed. The findings indicate a low concern for mutagenicity.

Mammalian Toxicology - Subchronic Toxicity. Data from repeated-dose toxicity studies were reviewed. No signs of toxicity were observed following repeated oral or dermal exposure.

Mammalian Toxicology - Reproductive and Developmental Toxicity. Data from a reproductive/developmental toxicity screening study were reviewed. No signs of reproductive or developmental toxicity were observed following repeated oral exposure. These findings are bridged to the other member of the category.

Conclusion. Based upon the data reviewed for this test plan, the individual physicochemical, environmental fate and toxicological properties of the proposed succinimide dispersant category, members are similar and/or follow a regular, predictable pattern based on structural similarity and can be grouped together.

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1.0 INTRODUCTION

In March 1999, the Petroleum Additives Panel Health, Environmental and Regulatory Task Group (HERTG) of the American Chemistry Council, and its participating member companies, committed to address certain chemicals listed under the Environmental Protection Agency (EPA) High Production Volume (HPV) Chemical Challenge Program. This final submission completes that commitment for the following substances:

- 2,5-Pyrrolidinedione,1-[2-[[2-[[2-[(2-aminoethyl)amino]ethyl]amino]ethyl]amino] ethyl]-, monopolyisobutenyl derivatives – (CAS # 67762-72-5), referred to as “mono alkenyl succinimide derivative”.
- Amines, polyethylenepoly-, reaction products with succinic anhydride polyisobutenyl derivatives – (CAS # 84605-20-9), referred to as “bis alkenyl succinimide derivative”.

2.0 CHEMISTRY OF SUCCINIMIDE DISPERSANTS

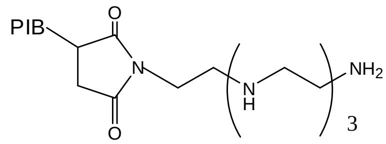
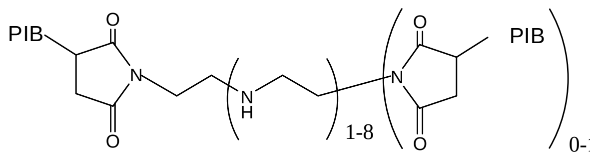
2.1 Description

Succinimide dispersants consist of a polyisobutylene hydrocarbon chain connected to a polyethylene polyamine substituent group by a succinic anhydride linking group. The polyisobutylene portion of the molecule is a saturated branched hydrocarbon of that may vary from 950 to 2500 daltons in molecular weight. The polyethylene polyamine substituent group may vary from diethylenetriamine to a “heavy polyamine”, which contains from 5 to 10 ethylene amine groups. The chemical names and CAS numbers for the members of the succinimide dispersant category are presented in Table 1 and the chemical structures in Table 2.

Table 1. Members of the Succinimide Dispersant Category

CAS Number	Chemical Name	**Simplified Chemical Name**
67762-72-5	2,5-Pyrrolidinedione,1-[2-[[2-[[2-[(2-aminoethyl)amino]ethyl]amino]ethyl]amino] ethyl]-, monopolyisobutenyl derivatives	Mono alkenyl succinimide derivative
84605-20-9	Amines, polyethylenepoly-, reaction products with succinic anhydride polyisobutenyl derivatives	Bis alkenyl succinimide derivative

Table 2. Chemical Structures of Succinimide Dispersants

CAS Number	Chemical Structure
67762-72-5	 67762-72-5 PIB= Polyisobutylene 500-2500MW
84605-20-9	 84605-20-9 PIB= Polyisobutylene 500-2500MW

These substances are prepared by reacting polyisobutylene succinic anhydride with a polyethylene polyamine in highly refined lubricating base oil. Thus the “active ingredients” are never isolated during the life cycle of these substances. This is done for two reasons: 1) the kinetics of the chemical reactions used in the manufacturing process are optimized when highly refined lubricating base oils are used as the reaction solvent, and 2) lubricant additives diluted in highly refined lubricating base oils are required to control viscosities during blending with other additives or with additional highly refined lubricating base oil to make finished lubricants. To meet the required viscosities for these substances, the concentration of highly refined lubricating base oil ranges from 25 wt% to 35 wt%.

There are two structural variables that influence the molecular weight of the category members and consequently their bioavailability and toxicity: the polyethylene polyamine and the isobutylene subtituents. As mentioned above, the polyethylene polyamine substituent group may vary from diethylenetriamine (102 daltons in molecular weight) to a “heavy polyamine” (231 to 446 daltons in molecular weight). Although the distribution frequency of the number of ethylene amine groups in heavy polyamine ranges from 5 to 10, the relative proportions of each distribution frequency are expected to be similar to meet industry performance requirements. However, the structural variable that has the greatest impact on the molecular weight of these molecules is the molecular weight of the polyisobutylene group. The carbon chain length of the 950 dalton polyisobutylene is approximately C68, and the carbon chain length of the 2200 dalton polyisobutylene is approximately C160. Linking more than one polyisobutylene succinic anhydride group to the polyethylene polyamine to form a “bis” molecule essentially doubles the molecular weight. As the alkyl carbon chain increases and molecular weight increases, bioavailability is expected to decrease. In addition, as the alkyl carbon chain length increases, water solubility is expected to decrease. Thus, aquatic toxicity is expected to decrease with increasing alkyl carbon chain length. Consequently, the members of this category are arrayed by increasing molecular weight, which is primarily dependent on polyisobutylene carbon chain length, and, to a lesser extent, on the number of ethylene amine groups in the polyethylene polyamine.

2.2 Uses of Succinimide Dispersants

Succinimide dispersants are used to formulate finished lubricating oils including all types of automotive and diesel engine crankcase oils, air and water-cooled two-cycle engine oils, natural gas engine oils, marine trunk piston engine oils, and medium-speed railroad diesel engine oils. They are used as ashless dispersants to inhibit colloidal particle-to-particle aggregation by an adsorbed film mechanism, and they solubilize oil-insoluble liquids. Succinimide dispersants are generally sold to finished oil blenders in additive packages, where the concentration ranges from 5 to 50 wt.%. These additive packages are then blended into finished oils where the typical concentration of succinimide dispersant ranges from 0.5 to 10 wt.% in the finished oil.

Succinimide dispersants in this category are manufactured at plants owned by members of the HERTG and blended into additive packages at plants owned by members of the HERTG and their customers. Finished lubricants are blended at facilities owned by HERTG's customers. Additive packages are shipped to customers in bulk in ships, isocontainers, railroad tank cars, tank trucks or in 55-gallon steel drums. The bulk additive packages are stored in bulk storage tanks at the customer blending sites. Finished oils are blended by pumping the lubricating oil blend stocks and the additive package from their storage tanks through computer controlled valves that meter the precise delivery of the components into a blending tank. After blending, the finished lubricant products are sold in bulk and shipped in tank trucks to large industrial users, such as manufacturing facilities and facilities that service truck fleets and passenger motor vehicles. Finished lubricants are also packaged into 55-gallon drums, 5-gallon pails, and one-gallon and one-quart containers for sale to smaller industrial users. Sales of lubricants in one-gallon and one-quart containers to consumers at service stations or retail specialty stores also occur.

Based on these uses, the potentially exposed populations include (1) workers involved in the manufacture of succinimide dispersants, blending them into additive packages, and blending the additive packages into finished lubricants; (2) quality assurance workers who sample and analyze these products to ensure that they meet specifications; (3) workers involved in the transfer and transport of succinimide dispersants, additive packages or finished lubricants that contain them; (4) mechanics who may come into contact with both fresh and used lubricants while working on engines or equipment; (5) gasoline station attendants and consumers who may periodically add lubricating oil to automotive crankcases; and (6) consumers who may change their own automotive engine oil. The most likely route of exposure for these substances is skin and eye contact. Manufacturing, quality assurance, and transportation workers will likely have access to engineering controls and wear protective clothing to eliminate exposure. Mechanics wear protective clothing, but often work without gloves or eye protection. Gasoline station attendants and consumers often work without gloves or other protective equipment. The most likely source of environmental exposure is accidental spills at manufacturing sites and during transport.

3.0 PHYSICOCHEMICAL PROPERTIES

The physicochemical properties of the members of the succinimide dispersant category are presented in Table 3. Succinimide dispersants, as manufactured and distributed in commerce in highly-refined lubricating base oil, are dark brown viscous liquids. These substances exist in the absence of base oil as idealized structures only. Attempts to "de-oil" succinimide dispersants result in substances that are solid materials that do not retain their original chemical structure and physico-chemical properties that are critical for performance. Therefore, the measured physico-chemical properties presented in Table 3 are derived from the succinimide dispersant in highly refined lubricating base oils and the modeled physico-chemical data are based on the idealized structure (Table 4).

Table 3. Measured Physicochemical Properties of Succinimide Dispersants

CAS Number	Molecular Weight	Specific Gravity[1] (g/ml)	Viscosity[2] (cSt @ 40°C)	Melting Point (°C)	Boiling Point (°C)	Vapor Pressure Pa	Water Solubility (mg/L)	Log Kow
67762-72-5	1134	0.9135	1330	NDA[3]	NDA[3]	NDA[3]	0.125	6.7
84605-20-9	2859-3160	0.9071	1100	NDA[3]	NDA[3]	NDA[3]	NDA[4]	NDA[4]

[1]ASTM D1298-99, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
[2]ASTM D 445-97, Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)
[3]No data could be located; calculated values given in Table 4.
[4]No data could be located; bridging to CAS Number 67762-72-5.

Table 4. Calculated Physicochemical Properties of Succinimide Dispersants using EPIWIN

CAS Number	Molecular Weight	Melting Point (°C)	Boiling Point (°C)	Vapor Pressure (Pa)	Water Solubility (mg/L)	Log K_{ow}
67762-72-5*	776.3	349.8	841.5	6.1E-19	1.8E-11	13.8
84605-20-9**	1277.2	349.8	1271.5	3.3E-31	3.1E-30	31.8

* The chemical structure used to model data included a PB moiety (Table1) of approximately 500 daltons or a total carbon number of C48.
** The chemical structure used to model data included PB moieties (Table1) of approximately 500 daltons each or a total carbon number of C48.

3.1 Molecular Weight

The members of the category range in molecular weight from 1134 to 3160 daltons. The two structural variables that influence the molecular weight of the category members have been discussed above. Due to the influence of molecular weight on water solubility and bioavailability, the members of the category are arrayed in order of increasing molecular weight in Tables 3-10.

3.2 Specific Gravity

Available specific gravity data are presented in Table 3. The specific gravity of the members of the category as manufactured in highly refined lubricating base oil is approximately 0.91 @ 60^oF.

3.3 Melting Point and Boiling Point

Succinimide dispersants, as manufactured in highly refined lubricating base oils, are liquid at ambient temperature. The use of these substances in finished lubricants requires that they be thermally and chemically stable under high temperatures (>100^oC). Typically, the petroleum base stocks in these substances boil at temperatures above 300^oC. Modeling data for the theoretical "de-oiled" substances indicates that the boiling point is 841.5 ^oC to 1271.5 ^oC (Table 4).

3.4 Vapor Pressure and Viscosity

As mentioned above, attempts to "de-oil" succinimide dispersants result in substances that are solid materials. Calculated vapor pressure values are given in Table 4 and range from 6.1×10^{-19} to 3.3×10^{-31} Pa @ 25^oC. The vapor pressure of the succinimide dispersants as manufactured in highly refined lubricating base oil can be estimated from the vapor pressure of the base oil in which they are manufactured. Typically, highly refined lubricating base oils have a low vapor pressure, $< 10^{-10}$ Pa @ 25^oC. In addition, the viscosity of these substances is also dependent on that of the highly refined lubricating base oil used in their manufacture. Measured viscosities range from 1100 to 1330 cSt @ 40^oC (Table 3). Thus, the low volatility of the members of the succinimide dispersants category is due to their low vapor pressure, high viscosity and high relative molecular weights.

3.5 Water Solubility and Octanol-Water Partition Coefficients

The water solubility of a representative succinimide dispersant, mono alkenyl succinimide derivative (CAS # 67762-72-5), was measured at 0.125 mg/L. This value indicates that succinimide dispersant are generally regarded to be insoluble in water. A log P value of 6.7 was also determined for this derivative (Table 3).

4.0 ENVIRONMENTAL FATA

4.1. Physicochemical Properties Relevant to Environmental Fate

Table 5. Evaluation of Environmental Fate Information for Succinimide Dispersants

CAS Number	Biodegradability	Atmospheric Oxidation	
	Available Data & Proposed Testing	OH^- Rate Constant (cm^3/molec-sec)	Half-life (hrs)
67762-72-5	No testing needed Bridging from CAS Number 84605-20-9	368.9E-12	0.3
84605-20-9	16% biodegraded after 28 days	214.8E-12	0.6

4.1.2 Biodegradability

Biodegradation data for the succinimide dispersant category are summarized in Table 5.

The Modified Sturm Test (OECD Guideline 301B, *CO_2 Evolution Test*) was used to evaluate the biodegradability of bis alkenyl succinimide derivative (CAS # 84605-20-9). After the 28-day test, the extent of biodegradation was 16% based on carbon dioxide evolution. The results indicate that this substance is poorly biodegraded.

The data will be bridged to both category members due to the presence of predominantly branched polyisobutylene chains in these substances, thereby characterizing the biodegradability of the entire category.

4.1.3 Hydrolysis

Although these substances contain amide functional groups that may be susceptible to hydrolytic degradative mechanisms[1], due to the low water solubility of this substance (0.125 mg/L), hydrolysis is not likely to occur. Further, while some amide groups may be susceptible to hydrolysis, this mechanism has been shown to be extremely slow (half-life greater than one year) with insignificant hydrolysis after 30 days at 25ºC and pH 5, 7 and 9 for hindered amide groups lacking suitable leaving groups.[2] The succinimide groups present in this substance are similarly hindered. Therefore, this substance is not susceptible to hydrolysis.

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[1] W.J. Lyman, W.F. Reehl, and D.H. Rosenblatt. (1982) Handbook of Chemical Property Estimation Methods. McGraw-Hill Book Co. New York, NY, USA.

[2] The C.P. Hall Company (2003) N.N-dimethylalkanamides HPV Test Plan. Available at http://www.epa.gov/chemrtk/pubs/summaries/dimetoct/c14154tc.htm

4.1.4 Photodegradation

The atmospheric oxidation potential of the selected chemical structures for members of the succinimide dispersant category is presented in Table 5. The modeling data indicates that the members of this category have a very low potential to photodegrade.

4.1.5 Fugacity Modeling

Fugacity-based multimedia fate modeling data for members of the succinimide dispersant category are presented in Table 6. All of the members of this category have low vapor pressure and low water solubility, and the modeling data indicate that they will partition into soil and sediment.

Table 6. Environmental Distribution of Representative Structures from Succinimide Dispersants as Modeled by EQC Level I

CAS Number	Air (%)	Water (%)	Soil (%)	Sediment (%)	Suspended Sediment (%)	Biota (%)	Fugacity (µPa)
67762-72-5*	0.00	0.00	97.75	2.17	0.07	0.01	2.8e-16
84605-20-9**	0.00	0.00	97.75	2.17	0.07	0.01	9.4e-28

* The chemical structure used to model data included a PB moiety of approximately 500 daltons or a total carbon number of C48.
** The chemical structure used to model data included PB moieties of approximately 500 daltons each or a total carbon number of C48.

5.0 ECOTOXICOLOGY DATA

5.1 Aquatic Toxicity of the Succinimide Dispersants

Acute aquatic ecotoxicity data for the succinimide dispersant category are summarized in Table 7. Both members of the category have been tested for acute aquatic toxicity in fish, daphnia and algae. A low order of toxicity was observed in all tests.

Table 7. Evaluation of Aquatic Toxicology of Succinimide Dispersants

CAS Number	ACUTE TOXICITY TO FISH 96-hr LL_{50} (mg/L)[1]	ACUTE TOXICITY TO INVERTEBRATES 48-hr EL_{50} (mg/L)[1]	TOXICITY TO ALGAE 96-hr EL_{50} (mg/L)[1]
67762-72-5	>1,000 (WAF[2], F)	>1,000 (WAF[3], D)	>1,000 (WAF[3], P, R) >1,000 (WAF[3], P, B)
84605-20-9	>1,000 (WAF[2], T)	>1,000 (WAF[3], D)	320 (WAF[3], P, R) 270 (WAF[3], P, B)

[1]Toxicity endpoints are expressed as median lethal loading rates (LL_{50}) for fish and median effective loading rates (EL_{50}) for *Daphnia* and algae. The EL/LL_{50} is defined as the loading rate that adversely effects 50% of the test organisms exposed to it during a specific time. The greater the EL/LL_{50} the lower the toxicity.
[2]WAF = Water accommodated fraction static renewal test.
[3]WAF = Water accommodated fraction static non-renewal test.
F = fathead minnow, *Pimephales promelas*.
D = freshwater cladoceran, *Daphnia magna*.
P = freshwater algae *Pseudokirchneriella subcapitata* formerly called *Selenastrum capricornutum*.
T = rainbow trout, *Oncorhynchus mykiss* formerly called *Salmo gairdneri.*
R = algae growth rate.
B = algae biomass.

5.1.1 Fish Acute Toxicity

Both substances in the category were evaluated for acute toxicity to fish. The maximum test material loading rate was 1000 mg/L, and no mortality was observed in the studies. Overall, the LL_{50} for both substances from both studies were greater than 1000 mg/L, indicating a relatively low order of toxicity to fish.

5.1.2 Invertebrate Acute Toxicity

Both substances in the category were evaluated for acute toxicity to *daphnids*. The maximum test material loading rate was 1000 mg/L. Overall, the EL_{50} for the two substances were greater than 1000 mg/L, indicating a relatively low order of toxicity to daphnids.

5.1.3 Alga Toxicity

Both substances in the category were evaluated for algal growth inhibition. The maximum test material loading rate was 1000 mg/L. Overall, the EL_{50} for these substances was greater than 100 mg/L indicating a relatively low order of toxicity to algae.

6.0 MAMMALIAN TOXICOLOGY DATA

6.1 Acute Mammalian Toxicity of Succinimide Dispersants

Acute toxicity data for the succinimide dispersant category is summarized in Table 8. Both members of the category have been tested by the oral and dermal route of administration and demonstrate a low order of acute toxicity.

Table 8. Evaluation of Acute Mammalian Toxicology of Succinimide Dispersants

CAS Number	ACUTE ORAL TOXICITY[1]	ACUTE DERMAL TOXICITY[1]
67762-72-5	LD_{50} > 5.0 g/kg (rat)	LD_{50} > 5.0 g/kg (rabbit)
84605-20-9	LD_{50} > 5.0 g/kg (rat)	LD_{50} > 2.0 g/kg (rat)

[1]Toxicity endpoints are expressed as median lethal dose (LD_{50}) for acute oral and dermal toxicity.

6.1.2 Acute Oral Toxicity

Both substances in the succinimide dispersant category have been adequately tested for acute oral toxicity. The acute oral LD_{50} for these studies in rats is greater than 5000 mg/kg (limit tests) indicative of a relatively low order of lethal toxicity.

6.1.3 Acute Dermal Toxicity

Both substances in the succinimide dispersant category have been adequately tested for acute dermal toxicity. The acute dermal LD_{50} for these studies in rabbits and rats were greater than 2000 mg/kg (limit tests). Overall, the acute dermal LD_{50} for these substances were greater than 2000 mg/kg indicative of a relatively low order of lethal toxicity.

6.2 Mutagenicity of the Succinimide Dispersant Category

A summary of the mutagenicity information for the succinimide dispersants is presented in Table 9. *In vitro* bacterial gene mutation assays and *in vitro* and *in vivo* chromosomal aberration assays have been conducted for both members of the category. Frequencies of reverse mutations in bacteria were not significantly changed after exposure to the succinimide dispersants. *In vitro* and *in vivo* chromosomal aberration studies indicate that succinimide dispersants are not clastogenic.

Table 9. Evaluation of Mutagenicity of Succinimide Dispersants

CAS Number	GENE MUTATION ASSAY	CHROMOSOMAL ABERRATION ASSAY
67762-72-5	Bacterial Reverse Mutation Assay – Not mutagenic	Mouse Lymphoma Mutagenicity Screen – Not clastogenic
84605-20-9	Bacterial Reverse Mutation Assay – Not mutagenic	Mouse Micronucleus Assay – Not clastogenic

6.2.1 Bacterial Gene Mutation Assay

Both substances in this category have been adequately tested in a bacterial reverse mutation test (OECD Guidelines 471 and/or 472). Both tested substances were negative for mutagenic activity, with and without metabolic activation.

6.2.2 Mammalian Gene Mutation Assay in Transformed Cells

One substance in this category was tested in an *in vitro* mouse lymphoma cell mutagenicity assay. The result of this study indicates that, in the absence and presence of hepatic microsome activation, succinimide dispersants are not mutagenic or clastogenic.

6.2.3 *In vivo* Chromosomal Aberration Assays

One of the substances in this category was tested in an *in vivo* chromosomal aberration. The test substance was negative for clastogenicity.

6.3 Repeated-dose Toxicity of Succinimide Dispersants

6.3.1 Summary of Repeated-Dose Toxicity Data

A summary of the results from the repeated-dose studies for the succinimide dispersant category is presented in Table 10. Repeated-dose toxicity tests have been performed on both members of the succinimide dispersant category by two routes of administration in rats.

Table 10. Evaluation of Repeated-dose Mammalian Toxicology of Succinimide Dispersants

CAS Number	REPEATED-DOSE TOXICITY	REPRODUCTIVE/DEVELOPMENTAL TOXICITY
67762-72-5	28-day repeated-dose dermal study in rats (OECD 410) NOEL = ~800 mg/kg/day (highest dose tested)	No testing needed Bridging
84605-20-9	4-week repeated-dose oral study in rats (OECD 407) NOEL = 1000 mg/kg/day At 1000 mg/kg/day, • No significant effects; At 500 mg/kg/day, • No significant effects; At 100 mg/kg/day, • No significant effects.	Reproduction/developmental oral toxicity screening test in rats (OECD 421) NOEL P0 = 1000 mg/kg/day NOEL F1 = 1000 mg/kg/day At 1000 mg/kg/day, • No significant effects; At 500 mg/kg/day, • No significant effects; At 100 mg/kg/day, • No significant effects.

6.3.1.2 Systemic Toxicity Tests

Both substances in the succinimide dispersant category have been tested for subchronic toxicity.

Mono alkenyl succinimide derivative (CAS # 67762-72-5) was evaluated in a 28-day repeated-dose dermal toxicity study in rats. There were no remarkable findings in this study for any of the endpoints evaluated. A NOAEL for systemic toxicity of ~800 mg/kg/day was established for this study.

Bis alkenyl succinimide derivative (CAS # 84605-20-9) was evaluated in a 28-day repeated-dose oral toxicity study in rats. There were no remarkable findings in this study for any of the endpoints evaluated. The NOAEL was established at 1000 mg/kg/day.

6.3.1.3 Reproduction and Developmental Toxicity Tests

Bis alkenyl succinimide derivative (CAS # 84605-20-9) was tested for reproduction and developmental toxicity. There were no remarkable findings in this study for any of the endpoints evaluated. The NOAEL was established at 1000 mg/kg/day.